Magnetic Soliton Pair Dynamics

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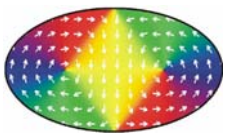
Motivation

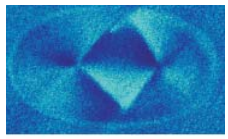
The dynamic properties of patterned nanomagnets are of fundamental interest and also determine their suitability for high-speed applications. Magnetic vortices possess a topological singularity that controls much of the interesting physics. Thus they are a type of soliton, a phenomenon observed in many physical systems. Magnetic vortices in confined geometries provide a model system for exploring the rich physics of dynamic soliton interactions.

Accomplishments

Magnetic soliton pair in confined geometry



Micromagnetic Model

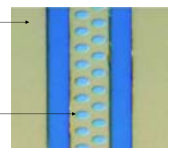


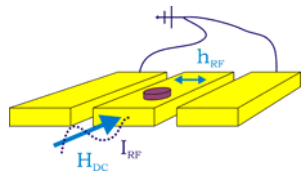
Magnetic Force Microscopy

The Experiment

co-planar waveguide (Au)

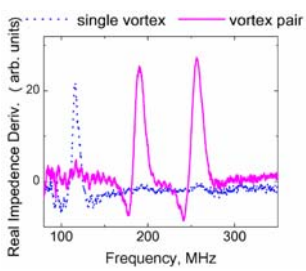
3 x 1.5 μm^2 x 40 nm ferromagnetic ellipses ($Ni_{80}Fe_{20}$ alloy)



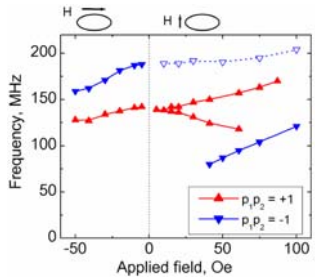


Microwave Reflection

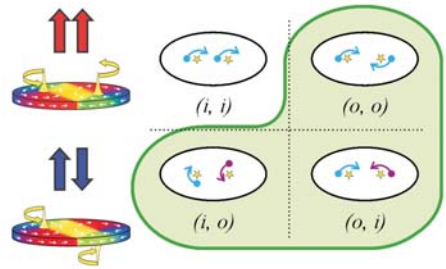
Results



The experimental spectra



Frequency vs. field dependence



Identified soliton pair excitation modes

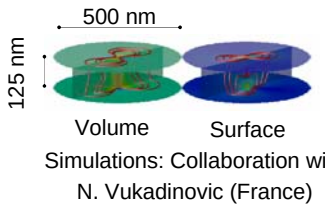
****Relative polarizations of the vortex cores controls the dynamics****

Future Directions

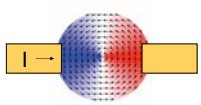
Magnetic vortices provide a model system for exploring many aspects of magnetization dynamics.

To be explored:

- High aspect-ratio structures
  - Moving beyond 2D
  - Test prediction of surface-localized vortex modes
- Nonlinear dynamics
  - Relevant to reversal instability problems
- Current driven dynamics
  - Interactions of spin polarized current with magnetic vortex

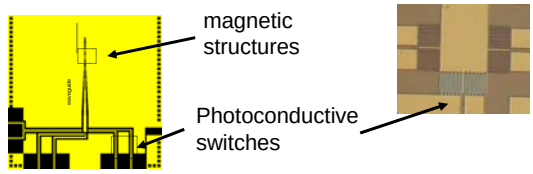


Simulations: Collaboration with N. Vukadinovic (France)



Ultrafast Magnetization Dynamics

- **Time-resolved PEEM in collaboration with ALS**



- Electron beam lithography (CNM)
- Spin structure is excited by an electrical pulse launched through a coplanar waveguide
- magnetization is probed using X-ray PEEM
- Sub-100nm spatial and sub-100ps temporal resolution

K. S. Buchanan, P. E. Roy, M. Grimsditch, F. Y. Fradin, K. Yu. Guslienko, S. D. Bader, and V. Novosad. Soliton pair dynamics in patterned ferromagnetic ellipses. Nature Physics 1, 172 (2005).

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